



EIGRP



Routing Protocols and Concepts – Chapter 9

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Objectives

- Describe the background and history of Enhanced Interior Gateway Routing Protocol (EIGRP).
- Examine the basic EIGRP configuration commands and identify their purposes.
- Calculate the composite metric used by EIGRP.
- Describe the concepts and operation of DUAL.
- Describe the uses of additional configuration commands in EIGRP.

Introduction

In this chapter, you will learn to:

- Describe the background and history of EIGRP.
- Describe the features and operation of EIGRP.
- Examine the basic EIGRP configuration commands and identify their purposes.
- Calculate the composite metric used by EIGRP.
- Describe the concepts and operation of DUAL.
- Describe the uses of additional configuration commands in EIGRP.

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector Routing Protocols		Link State Routing Protocols		Path Vector
Classful	RIP	IGRP			EGP
Classless	RIPv2	EIGRP	OSPFv2	IS-IS	BGPv4
	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

EIGRP

- **Roots of EIGRP: IGRP**

- Developed in 1985 to overcome RIPv1's limited hop count

- Distance vector routing protocol

- Metrics used by IGRP

- bandwidth (used by default)
- Delay (used by default)
- reliability
- load

- Discontinued support starting with IOS 12.2(13)T & 12.2(R1s4)S

IGRP to EIGRP



EIGRP

EIGRP Message Format

- EIGRP Header
 - Data link frame header - contains source and destination MAC address
 - IP packet header - contains source & destination IP address
 - EIGRP packet header - contains AS number
 - Type/Length/Field - data portion of EIGRP message

Encapsulated EIGRP Message

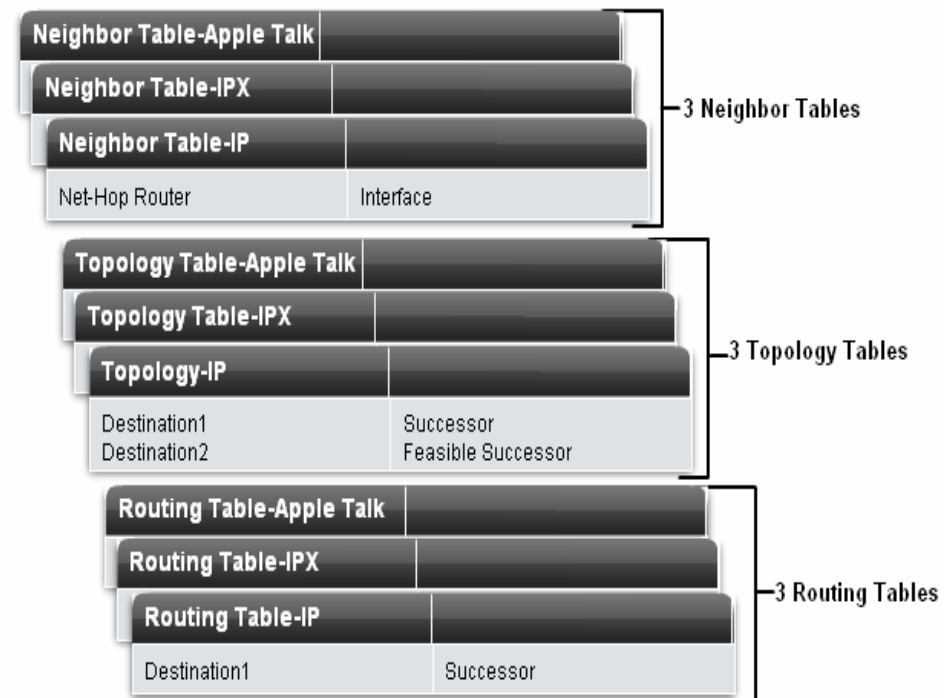


EIGRP

Protocol Dependent Modules (PDM)

- EIGRP uses PDM to route several different protocols i.e. IP, IPX & AppleTalk
- PDMs are responsible for the specific routing task for each network layer protocol

EIGRP Protocol-Dependent Modules (PDM)



EIGRP

Reliable Transport Protocol (RTP)

- **Purpose of RTP**

- Used by EIGRP to **transmit and receive EIGRP packets**

- **Characteristics of RTP**

- Involves both **reliable & unreliable delivery** of EIGRP packet

- Reliable delivery requires acknowledgment from destination

- Unreliable delivery does not require an acknowledgement from destination

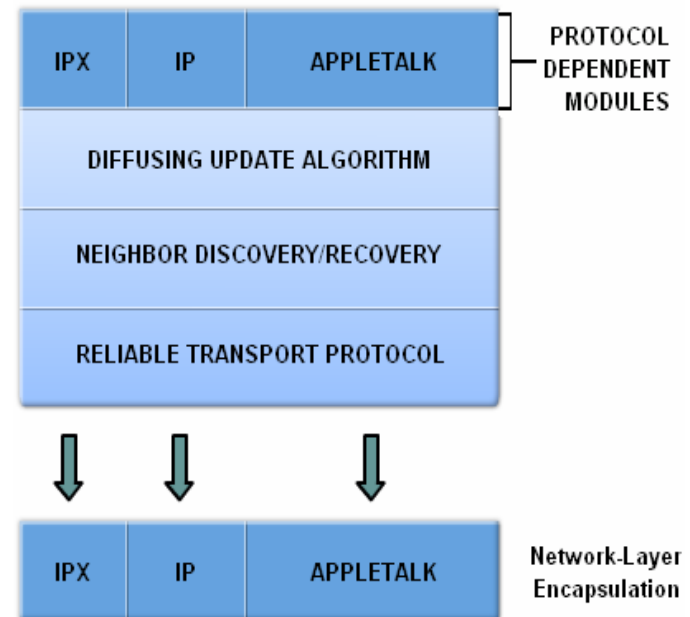
- Packets can be sent

- Unicast

- Multicast

- Using address 224.0.0.10

EIGRP Replaces TCP with RTP

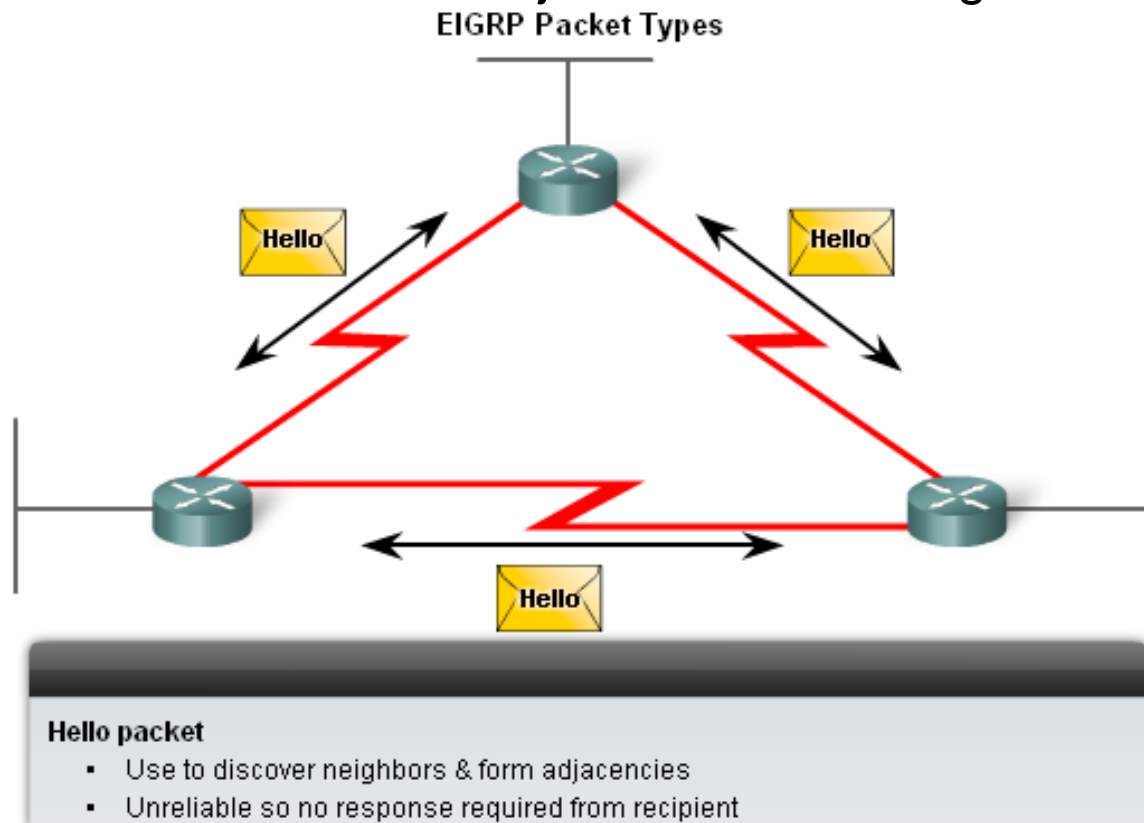


EIGRP

EIGRP's 5 Packet Types

- **Hello packets**

- Used to discover & form adjacencies with neighbors



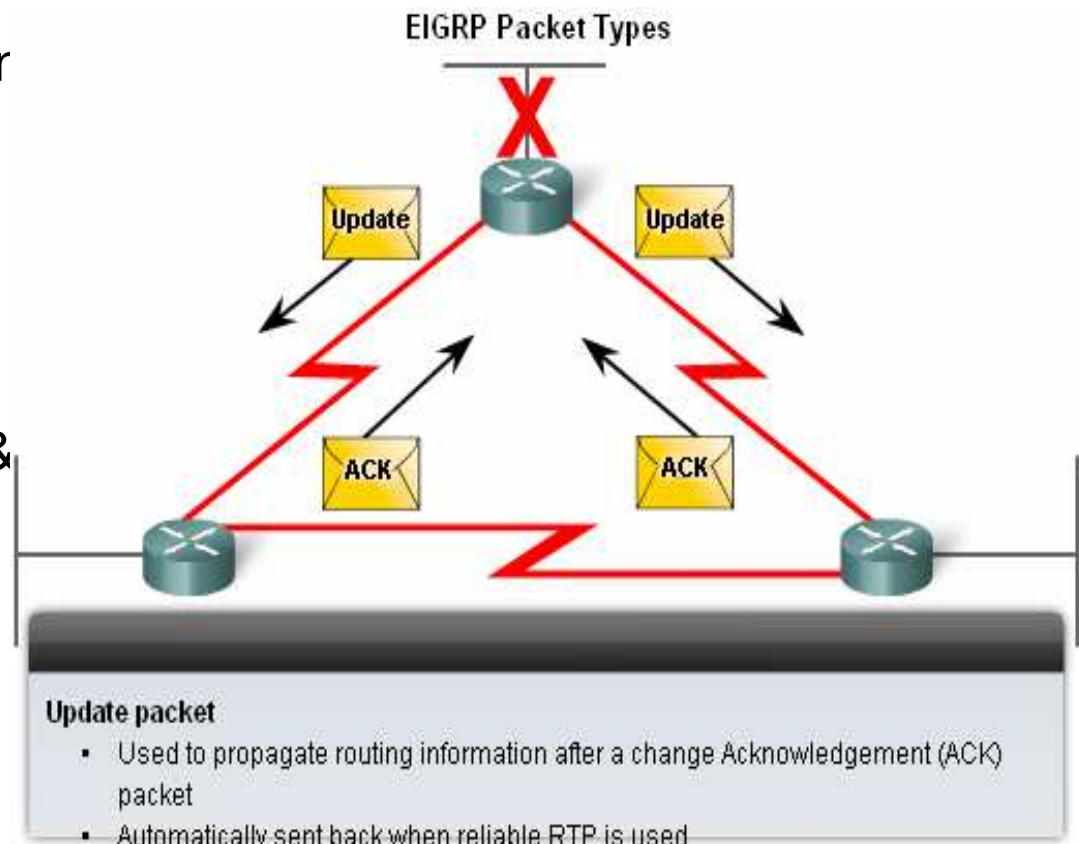
EIGRP

- **Update packets**

- Used to propagate routing information

- **Acknowledgement packets**

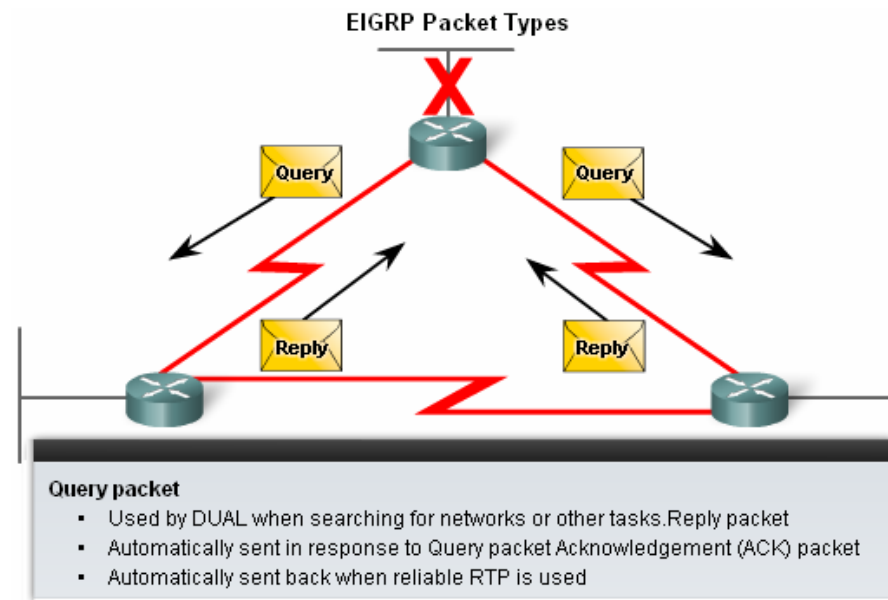
- Used to acknowledge receipt of update, query & reply packets



EIGRP

■ Query & Reply packets

- Used by DUAL for searching for networks
- Query packets
 - Can use
 - Unicast
 - Multicast
- Reply packet
 - Use only
 - unicast



EIGRP

- **Purpose of Hello Protocol**

- To discover & establish adjacencies with neighbor routers

- **Characteristics of hello protocol**

- Time interval for sending hello packet

- Most networks it is every **5 seconds**

- Multipoint non broadcast multi-access networks

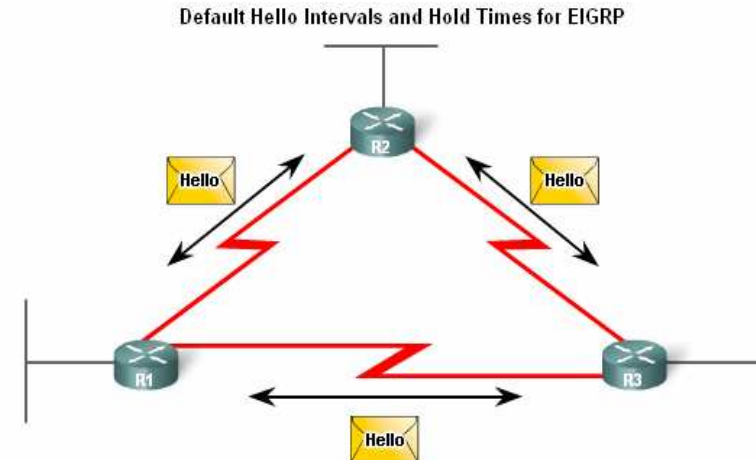
- Unicast every 60 seconds

- Holdtime

- This is the maximum time router should wait before declaring a neighbor down

- Default holdtime

- 3 times hello interval**



Bandwidth	Example Link	Default Hello Interval	Default Hold Time
1.544 Mbps	Multipoint Frame Relay	60 seconds	180 seconds
Greater than 1.544 Mbps	T1, Ethernet	5 seconds	15 seconds

EIGRP

EIGRP Bounded Updates

- EIGRP only sends update when there is **a change in route status**
- **Partial update**
 - A partial update includes only the route information that has changed – the whole routing table is NOT sent
- **Bounded update**
 - When a route changes, only those devices that are impacted will be notified of the change
- EIGRP's use of partial bounded updates minimizes use of bandwidth

EIGRP Updates

EIGRP Updates are partial and bounded:

Partial because the update only includes information about route changes.

Bounded because only those routers affected by the change will receive the update.

EIGRP

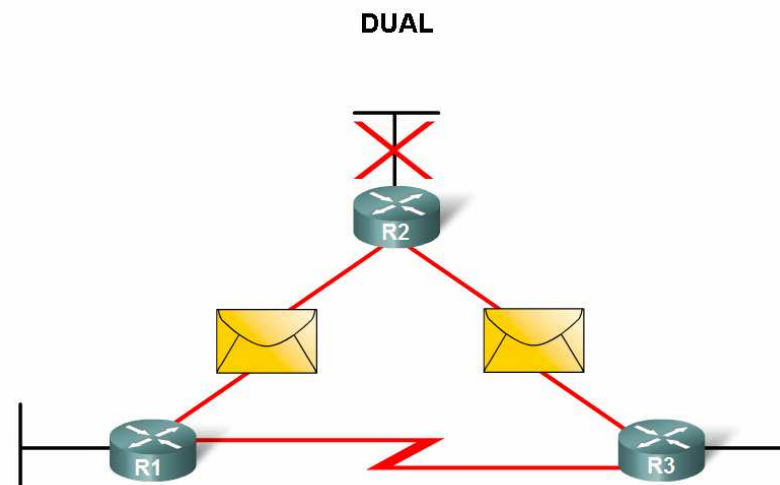
Diffusing Update Algorithm (DUAL)

–Purpose

- EIGRP’s primary method for preventing routing loops

–Advantage of using DUAL

- Provides for fast convergence time by keeping a list of loop-free backup routes



EIGRP

- Administrative Distance (AD)
 - Defined as the trustworthiness of the source route
- EIGRP default administrative distances
 - Summary routes = 5
 - Internal routes = 90
 - Imported routes = 170

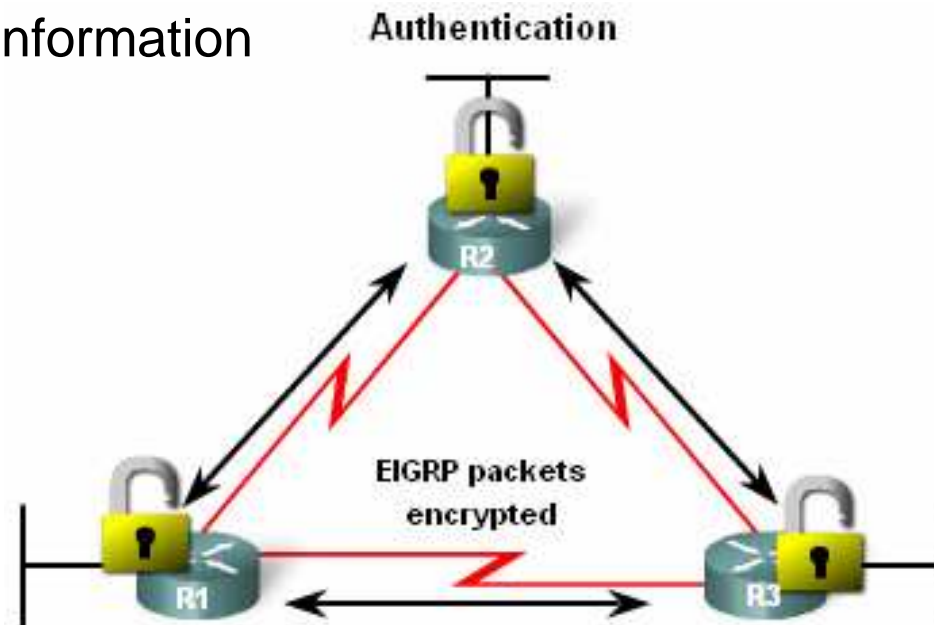
Default Administrative Distances

Route Source	Administrative Distance
Connected	0
Static	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
IGRP	100
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

EIGRP

Authentication

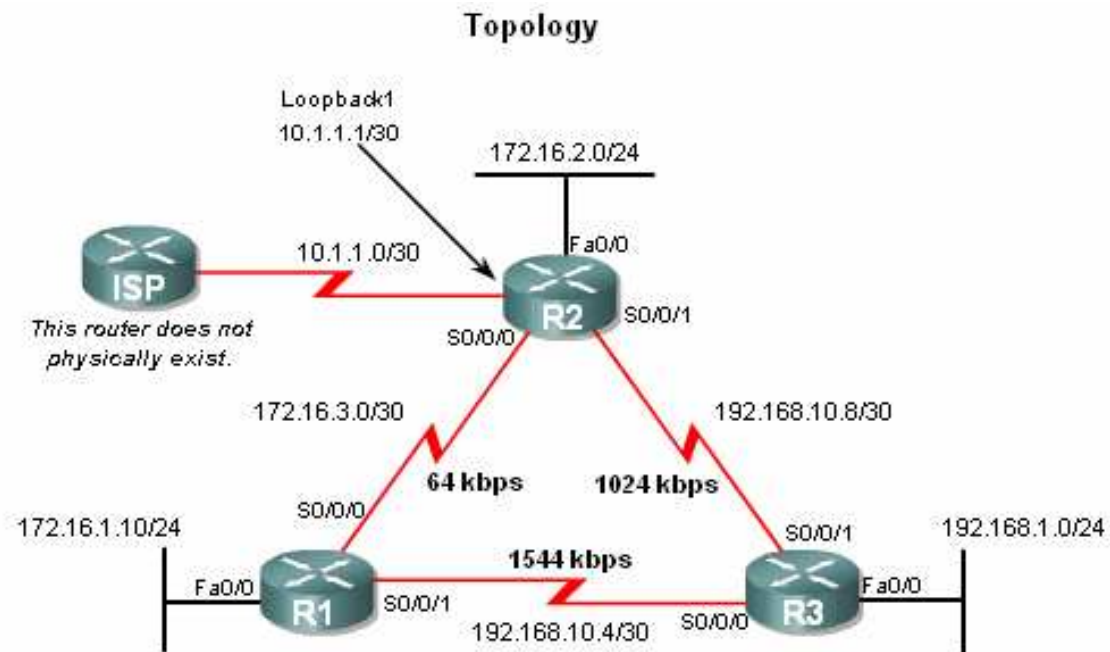
- EIGRP can
 - Encrypt routing information
 - Authenticate routing information



EIGRP

Network Topology

- Topology used is the same as previous chapters with the addition of an ISP router

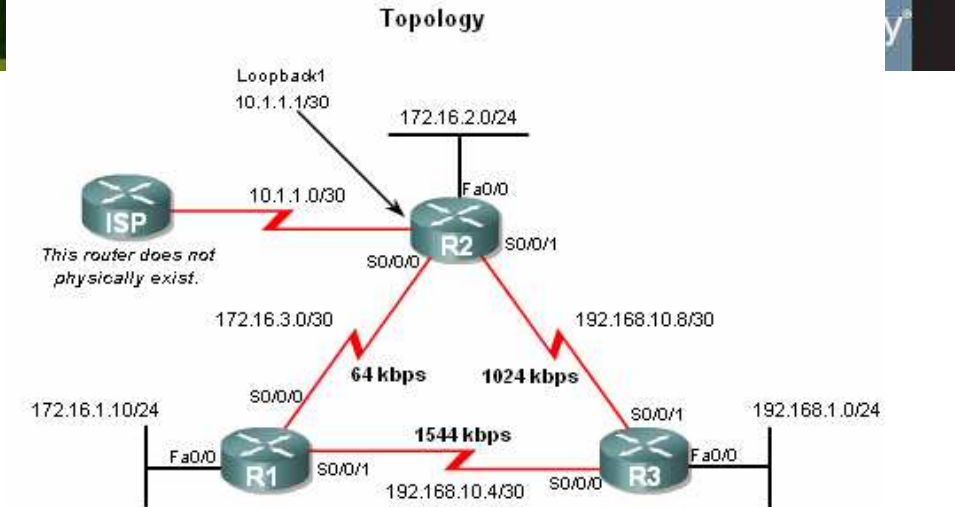


EIGRP

- EIGRP will automatically summarize routes at classful boundaries

Addressing Table

Device	Interface	IP Address	Subnet Mask
R1	Fa0/0	172.16.1.1	255.255.255.0
	SO/0/0	172.16.3.1	255.255.255.252
	SO/0/1	192.168.10.5	255.255.255.252
R2	Fa0/0	172.16.2.1	255.255.255.0
	SO/0/0	172.16.3.2	255.255.255.252
	SO/0/1	192.168.10.9	255.255.255.252
	Lo1	10.1.1.1	255.255.255.252
R3	Fa0/0	192.168.1.1	255.255.255.0
	SO/0/0	192.168.10.6	255.255.255.252
	SO/0/1	192.168.10.10	255.255.255.252



R1#show startup-config

```
<some output omitted>
!
hostname R1
!
interface FastEthernet0/0
 ip address 172.16.1.1 255.255.255.0
!
interface Serial0/0/0
 ip address 172.16.3.1 255.255.255.252
 clock rate 64000
!
interface Serial0/0/1
 description Link to R3
 ip address 192.168.10.5 255.255.255.252
!
end
```

R2#show startup-config

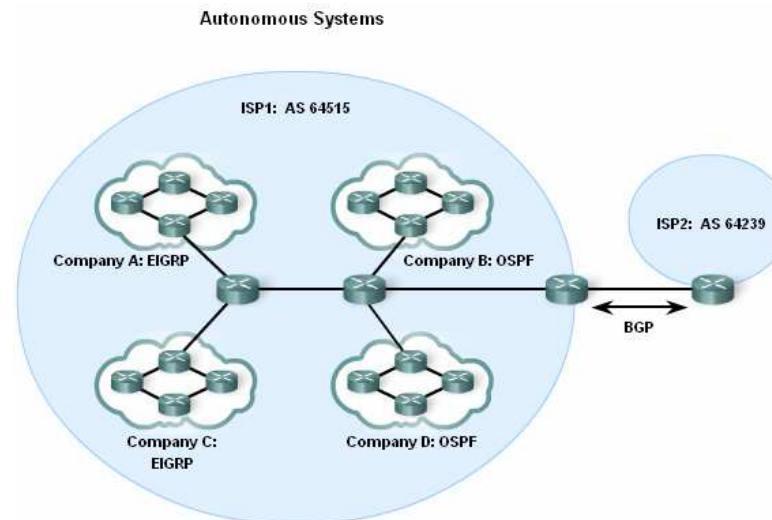
```
<some output omitted>
!
hostname R2
!
interface Loopback1
 ip address 10.1.1.1 255.255.255.252
 description Simulated ISP
!
interface FastEthernet0/0
 ip address 172.16.2.1 255.255.255.0
!
interface Serial0/0/0
 ip address 172.16.3.2 255.255.255.252
!
interface Serial0/0/1
 ip address 192.168.10.9 255.255.255.252
 clockrate 64000
```

R3#show startup-config

```
<some output omitted>
!
hostname R3
!
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
!
interface Serial0/0/0
 ip address 192.168.10.6 255.255.255.252
 clockrate 64000
!
interface Serial0/0/1
 ip address 192.168.10.10 255.255.255.252
!
```

Basic EIGRP Configuration

- Autonomous System (AS) & Process IDs
 - This is a collection of networks under the control of a single authority (reference RFC 1930)
 - AS Numbers are assigned by IANA
 - Entities needing AS numbers
 - ISP
 - Internet Backbone providers
 - Institutions connecting to other institutions using AS numbers

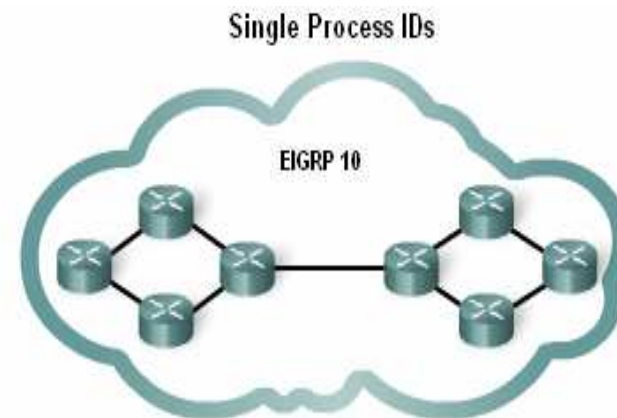


Basic EIGRP Configuration

- EIGRP autonomous system number actually functions as a process ID
- Process ID represents an instance of the routing protocol running on a router
- Example

Router(config)#router

eigrp *autonomous-system*



```

R1(config)#router eigrp ?
  <1-65535> Autonomous system number
R1(config)#router eigrp 10
  
```

Although the Cisco IOS refers to the router eigrp parameter as an "Autonomous system number", this parameter configures an EIGRP process—an instance of EIGRP running on the router—and has nothing to do with AS configurations in ISP routers.

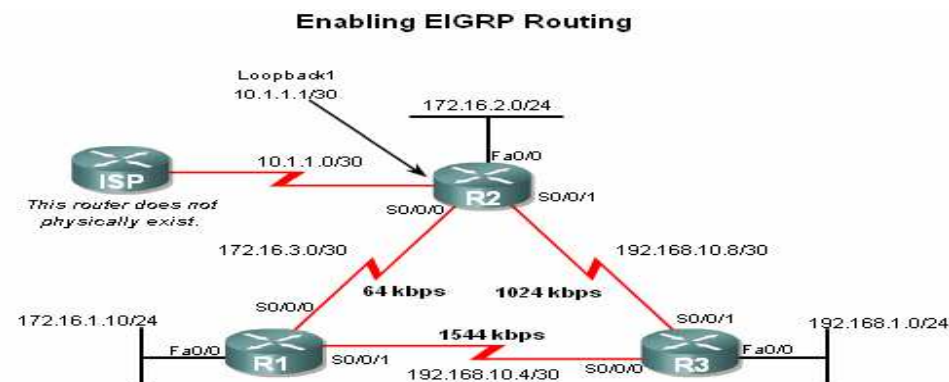
Basic EIGRP Configuration

The *router eigrp* command

- The global command that enables eigrp is

router eigrp **autonomous-system**

-All routers in the EIGRP routing domain **must use the same process ID number** (autonomous-system number)



```

R1(config)#router eigrp 1
R1(config-router)#

R2(config)#router eigrp 1
R2(config-router)#

R3(config)#router eigrp 1
R3(config-router)#
    
```

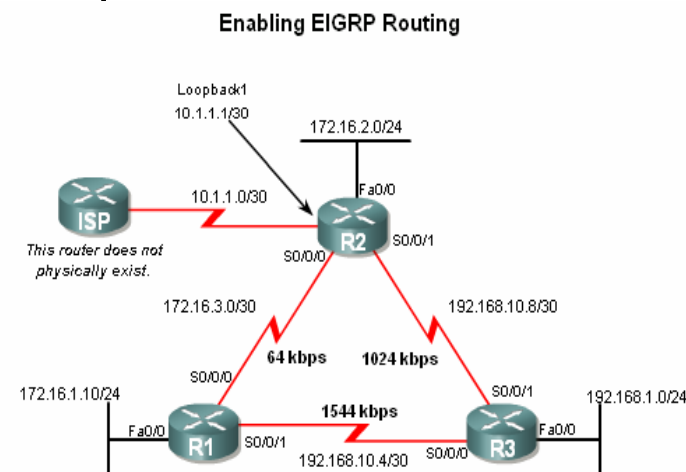
Basic EIGRP Configuration

The Network Command

- Functions of the network command
 - Enables interfaces to transmit & receive EIGRP updates
 - Includes network or subnet in EIGRP updates

- Example

- Router(config-router)#network



```

R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0

R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
    
```

Basic EIGRP Configuration

- The network Command with a Wildcard Mask
 - This option is used when you want to configure EIGRP to advertise specific subnets
 - Example

Router(config-router)#network network-address [wildcard-mask]

```
R1(config)#router eigrp 1
R1(config-router)#network 172.16.0.0
R1(config-router)#network 192.168.10.0
```

```
R2(config)#router eigrp 1
R2(config-router)#network 172.16.0.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 172.16.3.1 (Serial0/0/0) is up: new adjacency
R2(config-router)#network 192.168.10.8 0.0.0.3
```

```
R3(config)#router eigrp 1
R3(config-router)#network 192.168.10.0
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.5 (Serial0/0/0) is up: new adjacency
R3(config-router)#
%DUAL-5-NBRCHANGE: IP-EIGRP 1: Neighbor 192.168.10.9 (Serial0/0/1) is up: new adjacency
R3(config-router)#network 192.168.1.0
```

Basic EIGRP Configuration

Verifying EIGRP

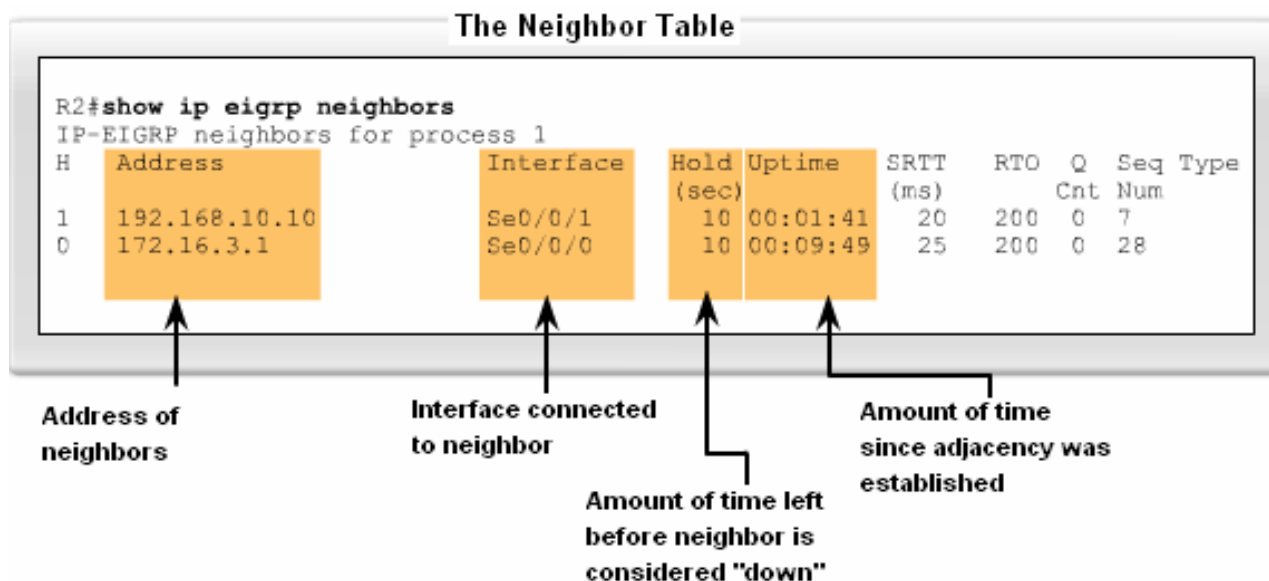
- EIGRP routers must establish adjacencies with their neighbors before any updates can be sent or received
- Command used to view neighbor table and verify that EIGRP has established adjacencies with neighbors is

show ip eigrp neighbors

The Neighbor Table

```

R2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address          Interface    Hold  Uptime    SRTT   RTO   Q   Seq Type
   192.168.10.10     Se0/0/1     10    00:01:41  20     200  0   7
   172.16.3.1        Se0/0/0     10    00:09:49  25     200  0  28
  
```



Address of neighbors (points to Address column)

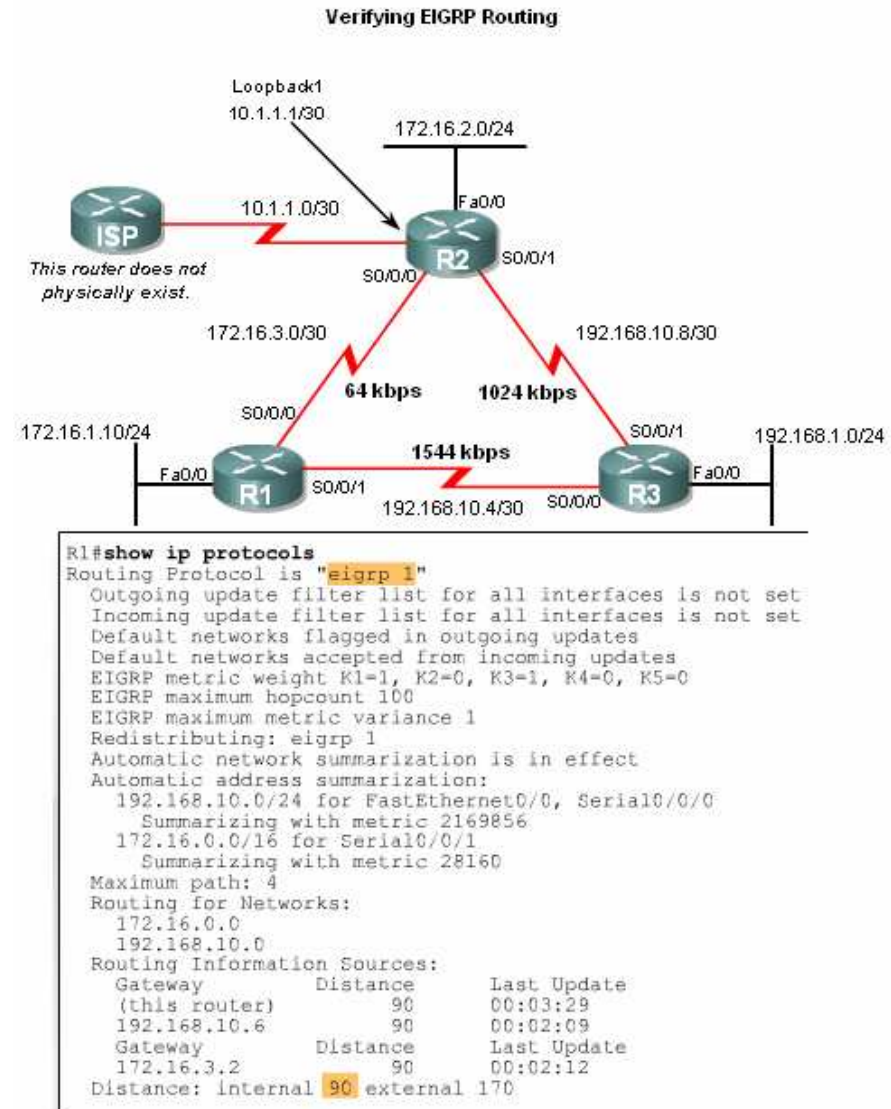
Interface connected to neighbor (points to Interface column)

Amount of time left before neighbor is considered "down" (points to Hold column)

Amount of time since adjacency was established (points to Uptime column)

EIGRP

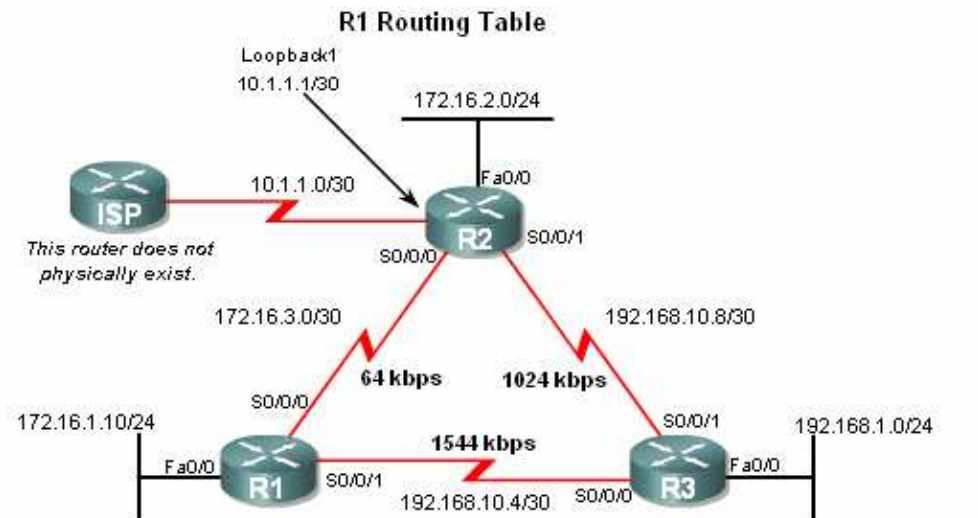
- The **show ip protocols** command is also used to **verify** that EIGRP is enabled



Basic EIGRP Configuration

Examining the Routing Table

- The **show ip route** command is also used to verify EIGRP
- EIGRP routes are denoted in a routing table by the letter “D”
- By default , EIGRP automatically summarizes routes at major network boundary



```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
<Output omitted>

Gateway of last resort is not set

 192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D   192.168.10.0/24 is a summary, 00:03:50, Null0
C   192.168.10.4/30 is directly connected, Serial0/0/1
D   192.168.10.8/30 [90/2681856] via 192.168.10.6, 00:02:43, Serial0/0/1
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D   172.16.0.0/16 is a summary, 00:10:52, Null0
C   172.16.1.0/24 is directly connected, FastEthernet0/0
D   172.16.2.0/24 [90/2172416] via 172.16.3.2, 00:10:47, Serial0/0/0
C   172.16.3.0/30 is directly connected, Serial0/0/0
D   192.168.1.0/24 [90/2172416] via 192.168.10.6, 00:02:31, Serial0/0/1
```

Basic EIGRP Configuration

■ Introducing the Null0 Summary Route

- Null0 is not a physical interface
- In the routing table summary routes are sourced from Null0
 - Reason: routes are used for advertisement purposes
- EIGRP will automatically include a null0 summary route as child route when 2 conditions are met
 - At least one subnet is learned via EIGRP
 - Automatic summarization is enabled

R2 Routing Table

```

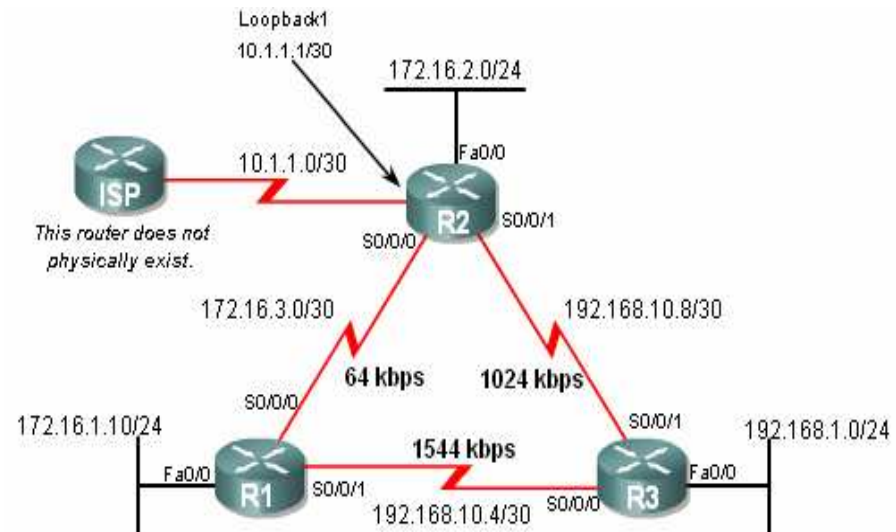
R2#show ip route
<Output omitted>

Gateway of last resort is not set

 192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D   192.168.10.0/24 is a summary, 00:04:13, Null0 Summary Routes to Null0
D   192.168.10.4/30 [90/2681856] via 192.168.10.10, 00:03:05, Serial0/0/1
C   192.168.10.8/30 is directly connected, Serial0/0/1
 172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D   172.16.0.0/16 is a summary, 00:04:07, Null0 Summary Routes to Null0
D   172.16.1.0/24 [90/2172416] via 172.16.3.1, 00:11:11, Serial0/0/0
C   172.16.2.0/24 is directly connected, FastEthernet0/0
C   172.16.3.0/30 is directly connected, Serial0/0/0
 10.0.0.0/30 is subnetted, 1 subnets
C   10.1.1.0 is directly connected, Loopback1
D   192.168.1.0/24 [90/2172416] via 192.168.10.10, 00:02:54, Serial0/0/1
    
```

Basic EIGRP Configuration

- R3's routing table shows that the 172.16.0.0/16 network is automatically summarized by R1 & R3



R3 Routing Table

```
R3#show ip route
<Output omitted>

Gateway of last resort is not set

  192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D   192.168.10.0/24 is a summary, 00:03:11, Null0
C   192.168.10.4/30 is directly connected, Serial10/0/0
C   192.168.10.8/30 is directly connected, Serial10/0/1
D   172.16.0.0/16 [90/2172416] via 192.168.10.5, 00:03:23, Serial10/0/0
    [90/2172416] via 192.168.10.9, 00:03:23, Serial10/0/1
C   192.168.1.0/24 is directly connected, FastEthernet0/0

Equal cost routes to 172.16.0.0/16
```

EIGRP Metric Calculation

EIGRP Composite Metric & the K Values

- EIGRP uses the following values in its composite metric
 - Bandwidth, delay, reliability, and load
- The composite metric used by EIGRP
 - formula used has values K1 →K5

K1 & K3 = 1
 all other K values = 0

EIGRP Composite Metric

Default Composite Formula:
 metric = **[K1*bandwidth + K3*delay]**

Complete Composite Formula:
 metric = **[K1*bandwidth + (K2*bandwidth)/(256 - load) + K3*delay] * [K5/(reliability + K4)]**
 (Not used if "K" values are 0)

Default values:
 K1 (bandwidth) = 1
 K2 (load) = 0
 K3 (delay) = 1
 K4 (reliability) = 0
 K5 (reliability) = 0

"K" values can be changed with the **metric weights** command.

```
Router (config-router) #metric weights tos k1 k2 k3 k4 k5
```

DUAL Concepts

- The **D**iffusing **U**ppdate **A**lgorithm (DUAL) is used to prevent looping

DUAL Concepts

DUAL provides:

- Loop-free paths
- Loop-free backup paths which can be used immediately
- Fast convergence
- Minimum bandwidth usage with bounded updates

DUAL Concepts

- Successor

The **best least cost route** to a destination found in the routing table

- Feasible distance

The **lowest calculated metric** along a path to a destination network

```

Feasible Distance and Successor
R2#show ip route
<code output omitted>

Gateway of last resort is not set

  192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D   192.168.10.0/24 is a summary, 00:00:15, Null0
D   192.168.10.4/30 [90/21024000] via 192.168.10.10, 00:00:15,
Serial0/0/1
C   192.168.10.8/30 is directly connected, Serial0/0/1
  172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D   172.16.0.0/16 is a summary, 00:00:15, Null0
D   172.16.1.0/24 [90/40514560] via 172.16.3.1, 00:00:15, Serial0/0/0
C   172.16.2.0/24 is directly connected, FastEthernet0/0
C   172.16.3.0/30 is directly connected, Serial0/0/0
  10.0.0.0/30 is subnetted, 1 subnets
C   10.1.1.0 is directly connected, Loopback1
D   192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
    
```

↑
↑
 feasible distance successor

R3 at 192.168.10.10 is the successor for network 192.168.1.0/24. This route has a feasible distance of 3014400.

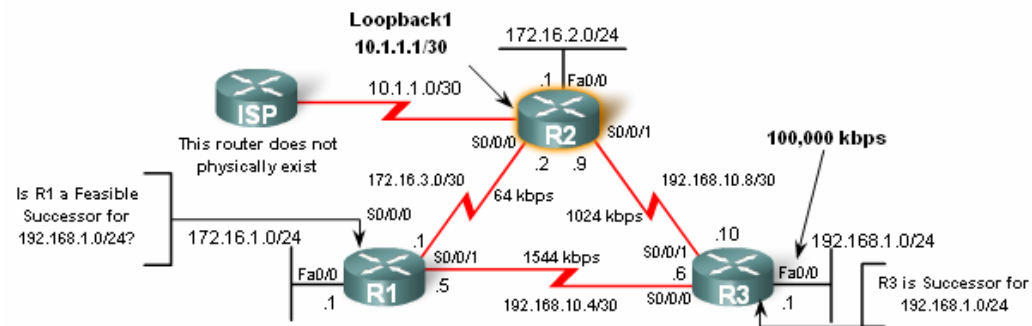
DUAL Concepts

Feasible Successors, Feasibility Condition & Reported Distance

- Feasible Successor

-This is a loop free backup route to same destination as successor route

Finding the Feasible Successor



```
R2#show ip route
<code output omitted>

Gateway of last resort is not set

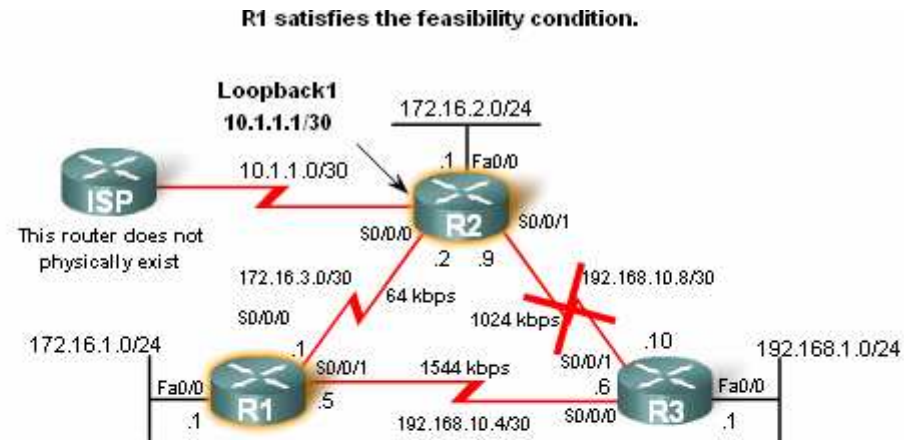
  192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
D   192.168.10.0/24 is a summary, 00:00:15, Null0
D   192.168.10.4/30 [90/21024000] via 192.168.10.10, 00:00:15, Serial0/0/1
C   192.168.10.8/30 is directly connected, Serial0/0/1
  172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
D   172.16.0.0/16 is a summary, 00:00:15, Null0
D   172.16.1.0/24 [90/40514560] via 172.16.3.1, 00:00:15, Serial0/0/0
C   172.16.2.0/24 is directly connected, FastEthernet0/0
C   172.16.3.0/30 is directly connected, Serial0/0/0
  10.0.0.0/30 is subnetted, 1 subnets
C   10.1.1.0 is directly connected, Loopback1
D   192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
```

DUAL Concepts

Feasible Successors, Feasibility Condition & Reported Distance

- Reported distance (RD)

-The metric that a router reports to a neighbor about its own cost to that network



```
R2#show ip route
<output omitted for brevity>

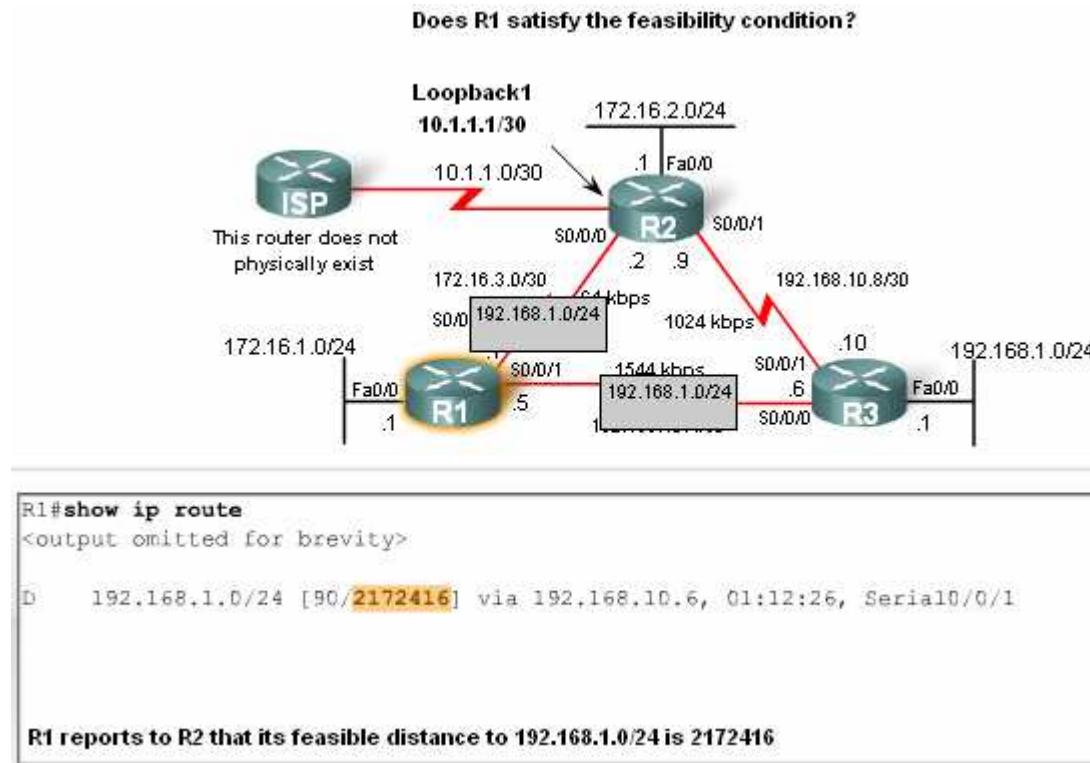
D   192.168.1.0/24 [90/3014400] via 192.168.10.10, 00:00:15, Serial0/0/1
-----

R1#show ip route
<output omitted for brevity>

D   192.168.1.0/24 [90/2172416] via 192.168.10.6, 01:12:26, Serial0/0/1
```

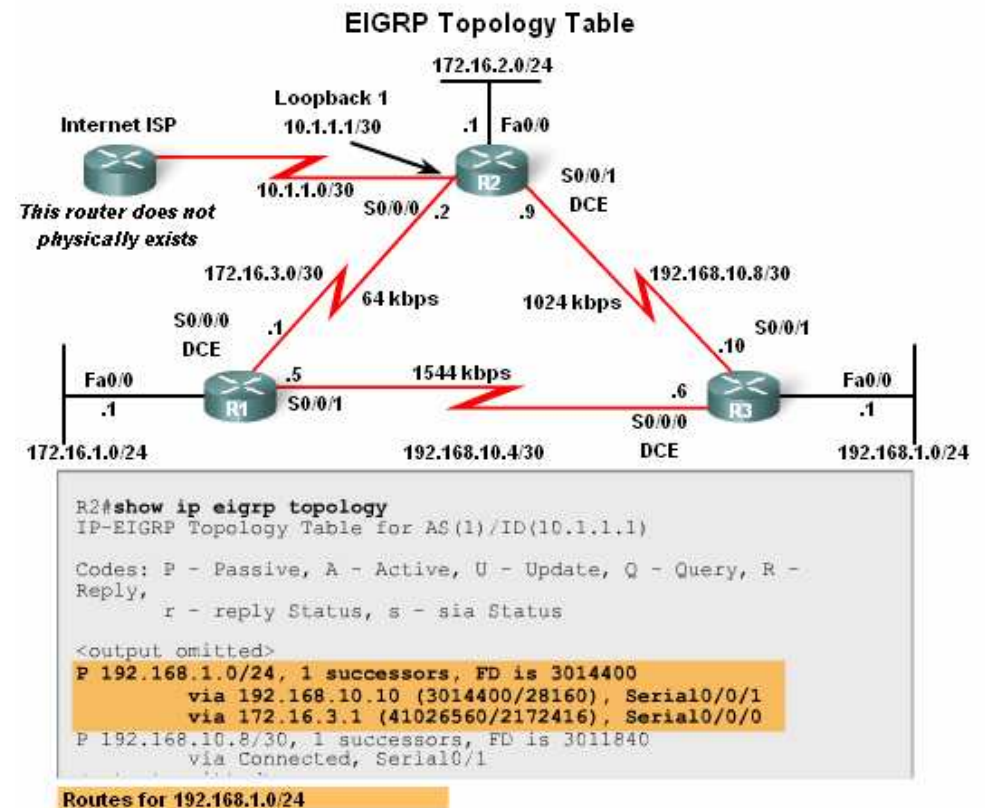

DUAL Concepts

- Feasibility Condition (FC)
 - Met when a neighbor's RD is less than the local router's FD to the same destination network



DUAL Concepts

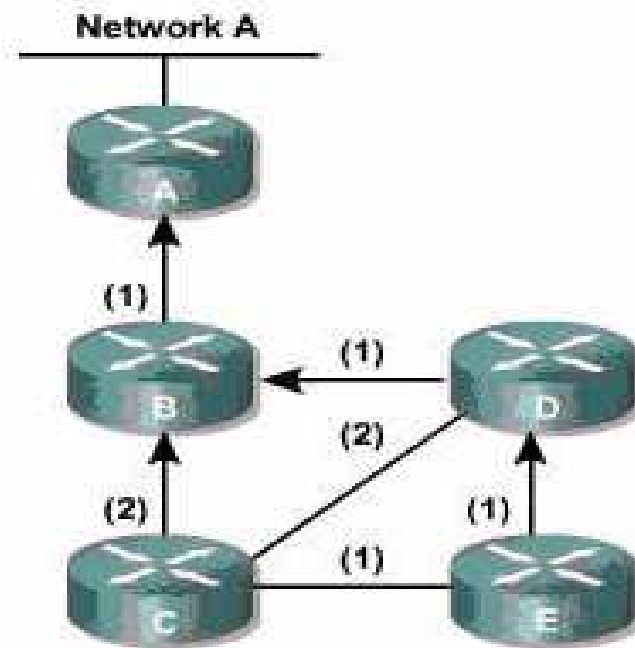
- Topology Table: Successor & Feasible Successor
- EIGRP Topology table
 - Viewed using the *show ip eigrp topology* command
 - Contents of table include:
 - all successor routes
 - all feasible successor routes



Example 1

From RouterC to Network A

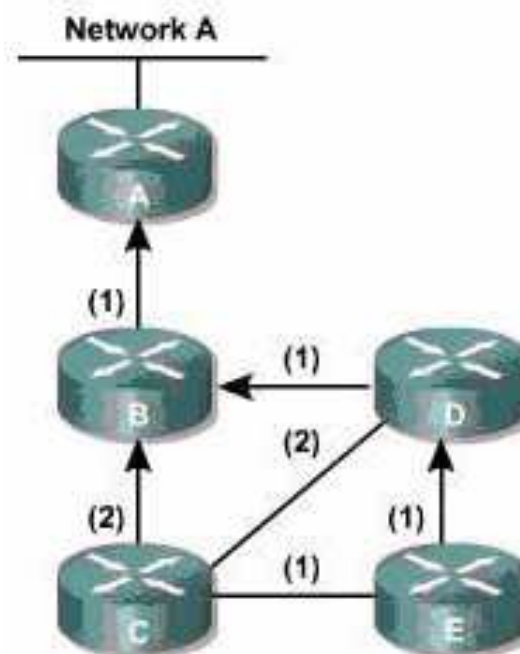
Next hop	Feasible Distance	Reported distance	Topologi
B	3		Successor
D	4	2	FS
E	4	3	



Example 2

From RouterD to Network A

Next hop	Feasible Distance	Reported distance	Topologi
B	2		Successor
C	5	4	
E	5	3	



More EIGRP Configurations

Disabling Automatic Summarization

- The ***auto-summary*** command permits EIGRP to automatically summarize at major network boundaries
- The ***no auto-summary*** command is used to disable automatic summarization
 - This causes all EIGRP neighbors to send updates that will not be automatically summarized
 - this **will cause changes** to appear in both
 - routing tables
 - topology tables

More EIGRP Configurations

Manual Summarization

- Manual summarization can include supernets

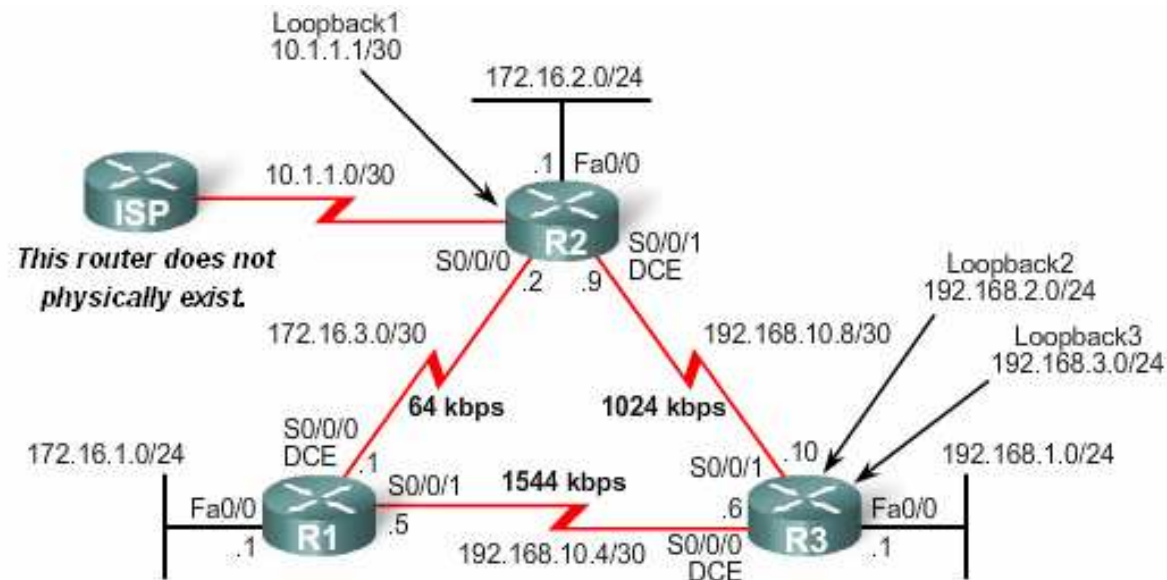
Reason: EIGRP is a classless routing protocol & include subnet mask in update

- Command used to configure manual summarization

–Router(config-if)#ip summary-address eigrp as-number
network-address subnet-mask

More EIGRP Configurations

- Configuring a summary route in EIGRP



```

R3(config)#interface serial 0/0/0
R3(config-if)#ip summary-address eigrp 1 192.168.0.0 255.255.252.0
R3(config-if)#interface serial 0/0/1
R3(config-if)#ip summary-address eigrp 1 192.168.0.0 255.255.252.0
    
```

Configure the summary route on all interfaces that send EIGRP packets.

More EIGRP Configurations

EIGRP Default Routes

- “quad zero” static default route
 - Can be used with any currently supported routing protocol
 - Is usually configured on a router that is connected a network outside the EIGRP domain
- EIGRP & the “Quad zero” static default route
 - Requires the use of the **redistribute static** command to disseminate default route in EIGRP updates

More EIGRP Configurations

Fine-Tuning EIGRP

- EIGRP bandwidth utilization

- By default, EIGRP uses only up to 50% of interface bandwidth for EIGRP information

- The command to change the percentage of bandwidth used by EIGRP is

Router(config-if)#*ip bandwidth-percent eigrp as-number percent*

EIGRP Bandwidth Utilization

```
R1(config)#interface serial 0/0/0
R1(config-if)#bandwidth 64
R1(config-if)#ip bandwidth-percent eigrp 1 50
```

```
R2(config)#interface serial 0/0/0
R2(config-if)#bandwidth 64
R2(config-if)#ip bandwidth-percent eigrp 1 50
```

More EIGRP Configurations

- Configuring Hello Intervals and Hold Times
 - Hello intervals and hold times are configurable on a per-interface basis
 - The command to configure hello interval is

Router(config-if)#*ip hello-interval eigrp as-number seconds*

- Changing the hello interval also requires changing the hold time to a value greater than or equal to the hello interval
 - The command to configure hold time value is

Router(config-if)#*ip hold-time eigrp as-number seconds*

```
R1(config)#int s0/0/0
R1(config-if)#ip hello-interval eigrp 1 60
R1(config-if)#ip hold-time eigrp 1 180
R1(config-if)#end
```

```
R2(config)#int s0/0/0
R2(config-if)#ip hello-interval eigrp 1 60
R2(config-if)#ip hold-time eigrp 1 180
R2(config-if)#end
```

Summary

- **Background & History**

- EIGRP is a derivative of IGRP

- EIGRP is a Cisco proprietary distance vector routing protocol released in 1994

- **EIGRP terms and characteristics**

- EIGPR uses RTP to transmit & receive EIGRP packets

- EIGRP has 5 packet type:

- Hello packets

- Update packets

- Acknowledgement packets

- Query packets

- Reply packets

- Supports VLSM & CIDR

Summary

- **EIGRP terms and characteristics**
 - EIGRP uses a hello protocol
 - Purpose of hello protocol is to discover & establish adjacencies
 - EIGRP routing updates
 - Aperiodic
 - Partial and bounded
 - Fast convergence

Summary

- **EIGRP commands**

- The following commands are used for EIGRP configuration

- RtrA(config)#router eigrp [autonomous-system #]
 - RtrA(config-router)#network *network-number*

- The following commands can be used to verify EIGRP

- Show ip protocols
 - Show ip eigrp neighbors
 - Show ip route

Summary

- **EIGRP metrics include**
 - **Bandwidth** (default)
 - **Delay** (default)
 - Reliability
 - Load

Summary

▪ DUAL

- Purpose of DUAL
 - To prevent routing loops
- Successor
 - Primary route to a destination
- Feasible successor
 - Backup route to a destination
- Feasible distance
 - Lowest calculated metric to a destination
- Reported distance
 - The distance towards a destination as advertised by an upstream neighbor

Summary

- **Choosing the best route**

- After router has received all updates from directly connected neighbors, it can calculate its DUAL

- 1st metric is calculated for each route

- 2nd route with lowest metric is designated successor & is placed in routing table

- 3rd feasible successor is found

- Criteria for feasible successor: it must have lower reported distance to the destination than the installed route's feasible distance

- Feasible routes are maintained in topology table

Summary

- **Automatic summarization**

- On by default
- Summarizes routes on classful boundary
- Summarization can be disabled using the following command
 - `RtrA(config-if)#no auto-summary`

